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Assessing Freshmen Engineering Students' Understanding of Engineering Ethics using Real- Time Scenarios

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Abstract: Engineering is an important and learned profession. As members of this profession, engineers are required to adhere to the highest principles of ethical conduct contributing to public safety and the environment. Engineering ethics must be framed and taught in a way that addresses these realities. Engineering ethics education should integrate seamlessly into engineering education. As compared to other disciplines in engineering, ethics in engineering is not given much importance. Training on these values is required to be relevant at undergraduate level for shaping students' ethical behaviours. This study explores the assessment of freshman engineering students' understanding on engineering ethics with real-time scenarios. An open-ended survey was conducted, and 23 students of freshman engineering were recruited to respond to the survey. The responses were analysed qualitatively. The demographic variable gender was specifically examined, and it is observed that female participants seem to have expressed more fully their responses with clear rationales in comparison with the male participants. Through the data analysis, it is observed that the real-time scenario survey questions helped students understand the importance of ethics in engineering. The outcome of this study can be used to introduce ethics in engineering in the form of workshops, webinars, courses, etc. depending on the need based on the students current understanding of engineering ethics. Future research will involve students from all the four years of engineering and their perception in engineering ethics which will help to better understand how to incorporate ethics in curriculum at different levels in the four-year program.

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1. Introduction

Owing to rapidly changing technology and environment around, ethics is and should be the core of engineering. Engineering ethics is the field of system of moral principles that apply to the practice of engineering. The field examines and sets the obligations by engineers to society, to their clients, and to the profession. Engineering ethics as a course has gained in popularity over the last decade, resulting in a branch of research and teaching known as engineering ethics [1]. Over the last decade, the field of engineering ethics has made substantial progress. Engineering ethics has been taught using a range of ways and methodologies that have been investigated and tested.

The ethical decisions and moral values of an engineer need to be considered because the decisions of an engineer have an impact the products and services - how safe they are to use, the company and its shareholders who believe in the goodwill of the company, the public and the society who trusts the company regarding the benefits of the people, the job and his moral responsibilities and about how the environment gets affected, etc. all the above shows positive influence of ethics in engineering [3].

Contrary, the field of engineering has no doubt simplified our lives and marked some unmistakable achievements in human history, engineering failures due to ethics are not new. From the sinking of Titanic in 1912 to the Fukushima Daiichi nuclear disaster in 2011, engineering failures have been caused by problems in design, construction and safety protocol. The blame can often be laid at ignorance, miscommunications and, in some extreme cases, indifference or negligence. After many of these engineering disasters however, professionals and leaders have learned from the wrong ethical decisions that were made. Rest

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assured, all these tragedies have left the new generation of engineers more cautious than ever. [4]

Engineering ethics education is existing in the system by various terminology like Universal human values (UHV) which is an initiative program taken by AICTE as FDP [5] where faculties are trained rigorously for 5 days and aimed to have absorbed a lot of knowledge on ethical values which is further targeted to imbibe on students at freshman level by orientation program for around 21 days in all engineering colleges. This exposure of training faculties under AICTE has created a buzz and people have started talking about human values in engineering education.

Decision making is an important part in ethics irrespective of the discipline or field. Some of the common examples of decision-making used in the engineering education which do not directly relate to ethics involve some sort of optimization techniques, which requires to eventually make decisions based on different attributes [6-11]. However, ethics in engineering is not as evidently present as other decision-making methods in engineering. A few exceptions include engineering ethics courses established by National Society for Professional Engineers, IEEE, Accreditation Board for Engineering and Technology (ABET), and at Texas A&M university where they address the need for ethics in the engineering curricula [12].

Engineering ethics is an old yet unexplored field in Indian universities. The major reason that motivated the author to conduct this study was to know about number of students that were aware of the concept and importance of engineering ethics. In this paper the study focuses mainly on assessing understanding of freshmen engineering students on engineering ethics using real-time scenarios.

2. Literature Review

The supporting literature for this study explores the real time scenarios to assess understanding of ethics in engineering students in their career. Teaching professional ethics and inspiring students to take moral values seriously are difficult tasks [13]. Case studies are the most widely used tool for studying engineering ethics [14]. Case studies can also help engineers get a stronger voice in big organizations [15]. Case teaching, according to [16] should assist in understanding engineering outputs from the perspective of the greater community. When students are confronted with inadequately and argumentative circumstances, cases are also employed to help them build decision-making abilities [17].

Teaching ethics is not a required necessity in many engineering programs. Engineering students, on the other hand, must exhibit that they are morally and skilfully grounded. Engineering programs must demonstrate that their graduates have a considerate professional and ethical duty, according to ABET's engineering criteria 2007, yet teaching engineering ethics is still not a high prominence in engineering education. [18]

Few authors argues that engineering ethics should be an independent academic discipline or a stand-alone credit course in the semester which will discuss about discipline specific issues within undergraduate engineering course [19]. You may first talk about engineering students in general and then highlight the fact that if the ethical lessons or modules are introduced in the first year then students will have more time to practice before they graduate [20]. There could be many reasons for this issue, such as lack of awareness of engineering ethics, lack of formal training to faculty on engineering ethics, unavailability of an expert in engineering ethics for guidance, being uninformed about the need of engineering ethics, being unclear about the process to be followed in engineering ethics [21].

Contrary it is that engineering ethics is now the subject of full-time study by numerous professional philosophers, social scientists, and other academics who research and write at the graduate level [22]. By learning ethical values at graduate level there may be impact at professional level students' unethical actions could correlate to future professional engineers' misconduct [23]. According to [24] it is said that "the study of the moral problems confronted by individuals and organizations involved in engineering.

It is recommended to teach ethics for undergraduate students in four aspects of academic dishonesty, punctuality, judgment, and behaviour. It further explores the impact of gender and academic disciplines on these four moral processes [25] and discussed about possible connection and other connections to perceptions of ethics involving gender, age, and engineering education. Engineering ethics course design can be aided by codes of ethics [26]. Codes, on the other hand, cannot replace individual capacities in resolving ethical challenges [27] or substitute for ethics education. There is widespread consensus in the literature that using case studies to teach engineering ethics is the most effective way [28]. Case studies have been recognized with effectively and interestingly introducing learners to the nuances and uncertainties of real-world moral considerations [29].

Despite of these significant advances, a large gap still retains in evaluating freshman engineering students understanding of engineering ethics using real time scenarios. In today's rapidly changing industry, there are also training requirements in order to generate the greatest potential ethical engineers.

3. Methods

For conducting this survey, the important part was to know the process we need to follow to come up with the appropriate interpretation. The author selected participants from the different disciplines to have a broader demographic variation. After collecting the data, the responses were assessed to evaluate the awareness in engineering ethics among freshmen engineering students using real time scenarios and to come up with solutions to help students imbibe ethical values which will help them professionally in future. In this study four real scenario-

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based questions were floated, and students' responses were recorded.

Procedure

Firstly, survey questions were designed, participants were selected from nine discipline based on their interest in the research topic followed by one hour of webinar session on basic definitions of engineering ethics with few real time scenarios were explained to 23 sample participants. Then after 3 days questions were floated in Qualtrics instrument by WhatsApp group into so that students completely get the essence of ethical questions and time limit was 48 hours after that link was deactivated.

Participants

Below is tabular format of pseudo names, gender, and discipline of targeted freshman students at affiliated engineering college.

Table 1. Demographic information of participants

S. No.	Pseudo Name	Gender	Discipline
1	Myra	Female	CSE
2	Riya	Female	Cyber security
3	Aachman	Female	CSE
4	Samay	Male	EEE
5	Malay	Male	CSE
6	Nidhi	Female	Mechanical
7	Aahan	Male	CSE
8	Sarthak	Male	IOT
9	Krishna	Female	Data Science
10	Sarahana	Female	Data Science
11	Aaradhya	Female	CSE
12	Kushagra	Male	Mechanical
13	Yash	Male	CSE
14	Dhruv	Male	CSE

4. Results and Analysis

Following are four scenario-based questions and 14 responses selected from the 23 freshman engineering students.

1. ***You have completed your assignment ahead of the due date and one of your friends is asking for help and the friend demands you to share your complete assignment with him/her. What will be your reaction in this case? Explain.***

rather than sharing my complete assignment to him/her, I will explain the question in that assignment and i will help him/her to write it by their own. So that it will make him/her to gain knowledge, inspire them to do their rest of the assignments by their own, and i my assignment is also safe (Myra).

I would first try to explain what was the questions asked in that assignment and explain later say them to answer by their own I always help my friends no matter if the person is he /her the thing is I explain and make the work done by their self only (Riya).

No as this is the only reason we should study ethics because every person has right to choose and take their decisions and they should know what they actually feels so they should tell their feelings and thoughts (Aachman).

Based on the participant's Myra, Riya and Aachman's responses, all of them did not fully agree to share assignment, they wanted their friend to understand the basic concepts of questions and do it on their own. They don't believe that their answers should get plagiarized like passing off another person's words and ideas as one's own. Some authors [30] assume that plagiarizing is not restricted to struggling students: it can also occur when students are under stress (for example, when work is due on a strict timeline or when a work is especially important for their marks); when students are uninterested in the work; and when students believe that the assignment is improper to the point where they have no chance of succeeding without cheating [31].

Few responses of the students who would like to share their assignments and help their friend were also recorded which are in support of finding lined up with studies who argued that present generation youngsters have brought up in a culture of "cut and paste," where collaboration and sharing are the standards, and many of their primary sources of information and knowledge, such as online resources, are viewed as lacking in authors. According to some academics, today's youth have a completely different perspective regarding copyright and authorship than prior generations. Others, on the other hand, suspects the problem is that students are not being educated how to respect academic honesty or how to integrate and correctly reference sources [32].

Now we have a generation young learners who have grown up with knowledge that appears to be floating around in internet with no apparent author. It's easy to believe that this data is freely available to anyone [33]. Student's responses can be correlated with the process that an engineer goes through in future, when it comes to offering credit for their efforts to others at employment, students must consider the same way. According to author [33] it is proposed that students should think and behave what they would do in that situation if their behavior were correct, or they have to modify. To overcome all these situations in profession there is urgent requirement of training freshman students in engineering education.

2. ***What would you do if you are caught cheating in your semester exam? Do you believe in academic dishonesty? What is your opinion as a student?***

A student cheats in exam because everyone judge a student by his grades only but not by his talent. Student have to study the subject although he is not interested in it (Samay).

As a student, I never believe in cheating in the exam. But incase it happens, from the student's point of view there are many thoughts. From one side, its wrong, since cheating is a malpractice and trying to get marks using malpractices, is not right. But if we take a look at the other side of the coin, its right. Because, many students aren't in suitable to conditions to equip their minds towards academics. Many students, have family problems (financial and mental), which don't allow them to concentrate on studies, inspite of them carrying the interest to study. Also, in such a situation there are many hopes and expectations from the student, which turn out to be a mental burden for them, traumatising them. In such a critical condition, they can't study properly. And in the examination, when they realise they have to pass at any cost, their, mind finds no other way, than cheating. And hence, they go for it. In such a situation, the student is right, and instead of punishing him/her, the concerned authorities needs to console them, take care of them, and get them out of their critical condition (Malay).

As a student, I would agree for it and apologize to the teacher. Academic dishonesty is not a good thing because in the long run its going to affect our self the most. Since, the current educational system targets students just to score marks and hardly concerns on gaining knowledge. This is an outcome of the same (Nidhi).

From Nidhi's response, it could be concluded that students do not rely on academic dishonesty, but few concerns are their where students tend to commit cheating and copying which are common forms of academic dishonesty used by them to gain good scores than they are worthy of. Despite the fact that the majority of them believe they are immoral and against ethical standards, Academic dishonesty must be overcome in order for individuals to have a bright and effective job prospect. The academic community is presently focusing its efforts on raising student ethical awareness, such as the ethics of reproducing data and exploiting information in the digital age.

It is critical to publish ethical standards of conduct and teach ethics courses, which have become an important part of basically every university topic and can help to combat academic dishonesty among students. Furthermore, studying students' mindsets, what they think about academic dishonesty, and why they learn it may help to resolve this trend, while increasing students' and lecturers' awareness of the risks and consequences of such acts by teaching ethical values in engineering disciplines may help to eradicate academic dishonesty to some extent. Exam cheating should be investigated in engineering academic institutions to help professional educators better comprehend academic dishonesty.

Based on the responses from Samay and Malay who tend to cheat in semester exam due to various reasons are lined with the finding of [34] author who argue that the following factors contribute to an increase in academic cheating: limited time students have to complete assignments ,Peer culture, external work commitments, websites that facilitate plagiarism, high family expectations, pressure for high academic achievement, heavy course loads, fear of future career damage, importance of good grades, competition with other students and lack of understanding of the concept of plagiarism. Furthermore, shifts in assessment (such as team projects), the technology and communications issue, an emphasis on getting good grades, and the perceived threat of employability all lead to a rise in stealing and plagiarism events.

Students' tendency to cheat or copy is influenced by a variety of circumstances. Some students, for example, find their task challenging or tedious, risk of failure, inadequate instruction, and may be under pressure due to a lack of study time and excessive workloads. [35, 36] has indicated that students who cheat on tests are more likely to engage in dishonest activities in the workplace than those who do not.

For faculty it's necessary to understand student's aspect and make them understand how academic dishonesty will affect their education and ultimately profession in long run. In the direction to handle these situations its necessary to imbibe ethical values at freshman level in engineering career because employers nowadays demand competent graduates who are ethical in order "to cope with the pressures and complexities of working in a rapidly changing, competitive environment" [37]. Although faculty passionately hope that academic dishonesty will vanish, unethical behaviors, such as cheating, and plagiarism are resistant to extinction [38].

3. ***One of the reason Titanic had sunk was due to faulty design by engineers. What is your opinion as an engineer?***

No it's completely a big mistake for not caring about the fault and going to other step.it is happen may be because we don't know how to solve it or maybe of lack of equipments/ guidelines (Aahan).

As an engineer, I would understand the need for the engineers to impress passengers by the decor. However I believe, choosing aesthetics over safety is not the right decision. Safety must always take top-most priority. When so many passengers have put their lives in the hand of these engineers, it is extremely irresponsible and unfair that the engineers to not give importance to their lives (Sarthak).

I did it right, as i want to impress passengers want to attract i did it (Krishna).

It is a blunder! Being an engineer it is important to know and work for the welfare of the people. Being selfish and greedy for one's profit is unethical. Keeping just the profit in mind, life of

> thousands of people including a few of themselves was lost. If i was an engineer of the same I wld not agree to move on without rectifying the problem. Cause impressing the passengers just by the decor wld last for a short period of time while working on the details wld make it sustainable (Sarhana).

From the participants Aahan, Sarthak and Sarahana, it is evident that they gave priority to ethics over aesthetics. It is suggested that engineers might have looked public safety prior. When engineers design a product, many things go into the decision-making process when it comes to selecting materials, design and the manufacturing processes. One concern that has always been in the decision-making process is trying to make sure the outcome will always be ethically good, although this isn't always the case. Safety is the key that engineers should keep in mind instead of profits, personal advancement, or anything else in front of people welfare.

Several instructors mentioned combining ethical concerns alongside technical issues or legal matters [39]. This approach is best explained by [40] who emphasizes the role of addressing technical questions alongside ethical questions to make students aware of the wider context and implications of their work. The outline to the NSPE Code of Ethics for Engineers states that engineers "require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Every engineer must adhere to above all ethical values in their engineering education.

Participant Krishna had shown confusion and supported aesthetics over safety that is the reason why engineering ethics must be taught in undergraduate courses because they should think ethically ultimately impacting society at larger context. In response to failures, engineers need to change professional procedures and practices so that they reinforce, rather than place obstacles in the way of, moral action.

It is useful to make a distinction between ethics in engineering and ethics of engineering [41]. Ethics in engineering addresses the ethics of actions of individual engineers. Ethics of engineering deals with ethical issues that involve the role of engineers in industry, the ethics of the organizations in which they work as well as of professional engineering societies, and the ethical responsibilities of the profession. Reactions to major failures can affect both types of engineering ethics.

4. **The class timings were scheduled from 9.30-10.30 am but due to some personal reason faculty starts the class at 10.00 am. In a meeting with the HOD when asked about the faculty punctuality and course completion what will be your reaction as a student?**

> I would look into the frequency of these late classes of they are fairly regular I would tell the HOD that the teacher is not punctual and has stated some personal reason but if the frequency is less then I wouldn't bother saying anything and would give a positive response and not mention the late classes because faculty is completing syllabus on time (Aaradhya).
>
> I would not choose to complaint because as students we are also facing network issues and some personal issues my will focus will be majorly on syllabus coverage (Kushagra).
>
> Definitely i would be in favor of the faculty, keeping pandemic period and online classes in mind .I would just acknowledge him. I would also tell faculty if there is any problem he or she can take the class later that day to finish portion and syllabus (Yash).
>
> If the faculty had it regularly then that would land up trouble or else everything would have been fine (Dhruv).

From the above responses, participant Aaradhya, Kushagra, Yash and Dhruv had responded in a constructive manner like they were ethically right it is good to understand other person's viewpoint because faculty can also have few reasons for not coming on time and delaying class hours. Students were more concerned about consistency in absenteeism of faculty. Their focus was more on syllabus coverage and learning outcomes they achieve from the course.

The above study is lined with finding were author [42] argued that one of the desirable ethical work practices is punctuality required for organization all over the world. Thus, the organization we work with expects us to be punctual to rely on us to achieve its target and success. Our consistent absence and tardiness may increase the workload on employees thereby negatively impacting the performance of the organization.

Before the semester begins faculty plan their courses with deadlines of topic. If faculty is adhering to semester plans and do not waste students time, effort and money and concentrate on how students learn, grow and develop then it is creating ethical environment in class which will help to improve knowledge skill and abilities. In brief faculty must focus on learning outcomes of their course syllabus and must be responsible to create a climate of importance of ethical behaviour to learning and academic development [43].

From all the above real time scenario responses few demographic variations were observed. For example, the trend in engineering discipline like computer branch and its applied sciences engineering discipline students show more tendency of expressing their views towards ethical values. Findings also suggested some gender variations were female participants responded more ethically in punctuality and academic dishonesty aspect than male. Where the findings showcase that female student seem to higher

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ethical perceptions in comparison to male students on perceiving the ethical roles and responsibilities. In support of [43] study, it was statistically proven that female students had higher ethical values than males. It is suggested for deeper analysis in justifying above gender and discipline trends. While most undergraduates have a fundamental understanding of ethical concepts, they simply need more training for understanding and dealing with the complicated and nuanced difficulties of professionalism in engineering before they face ethical issues in the real world [44].

However, engineering ethics as a course in affiliated colleges in India has been shown lesser extent of importance. Thus, present study will help to address gap to assess freshman students' perceptions of ethics in engineering education using real time scenarios. The author believes that ethics in engineering should be given serious consideration in engineering courses which ultimately will have vital impact on the decisions and actions of students now and in future.

5. Implications and Recommendations

By collecting and analysing student responses from the real time scenario survey questions, the author suggests that ethics in engineering can indeed be taught and will have a strong impact on students' personal beliefs and behaviours. The author further recommends that firstly at institutional level engineering ethics must be treated in par with engineering core subjects in all possible ways to attract more students' interest in engineering ethics. Second, there must be some local and national webinars for engineering ethics in affiliated/deemed/autonomous colleges in India so that ethical values in engineering will reach to a broader audience and will eventually help build a robust community of faculties who train student's basic ethical values to lead a good professional career which ultimately benefits society at large. Ultimately, the author recommends that there is a full scope for integrating ethics in engineering curriculum either as a core or as an elective course by using real time scenario or case studies as a pedagogical activity.

After conducting this study, it is highly recommended to have strong ethical values at organizational level, so that every individual may be students/faculties must feel the essence of ethical environment they are living in and transform their thinking and behaviour by stopping all malpractices like allowing students to cheat, leaking of assessment items, and giving attendance without attending classes. Hence, it is recommended to imbibe ethics to the core from organizational level to freshman student level which can be achieved by prioritizing the teaching and learning of ethics in their curricula or program using various pedagogical approach.

6. Conclusions

Engineering ethics is one of the most important part in any education system because it drives what kind of contents are thought that students are learning. One of the primary goals of engineering ethics is to guide students in providing the right learning experience from teachers. Result of analysis agrees on the importance of real time scenarios in assessing freshman students' perspectives on ethics engineering education. Where ethics in four years of engineering can be introduced by extracurricular activity in curriculum which will help students to discuss about major role of ethics in engineering and how training on these aspects will help them build a better professional at workplace.

Freshman engineering students need to be taught how to make a value decision, understand what is ethically important, and assess the impact of their actions which is in support of AICTE initiative taken to train faculty members on Universal Human Values (UHV) and to inculcate these values at freshman engineering level. Overall, the agenda of the UHV initiative is aligned with incorporating ethical values at freshman level in engineering education.

7. Future Work

While the current research provides a macro view of how freshman engineering college students assess ethics on campus using real time examples, future research will focus on a more in-depth examination of the differences in their assessment associated with participants gender, academic discipline, and freshman student perception from different affiliated, autonomous, and deemed colleges. Future research would even involve student's quantitative survey to collect data from the students of all the four years of engineering and their ethical perspective in engineering education using case studies which will help to better understand how to incorporate ethics in curriculum [45- 47]. Further research will be carried out by conducting qualitative interviews by using survey instrument for Defining and Assessing Engineering Ethics that can investigate deeper understandings and perceptions of ethics in engineering using real time scenarios [48-50]. Lastly, qualitative research studies can also be conducted to investigate the perceptions/opinions of the faculty member's perspectives on engineering ethics. Concept assessment tools can also be created and used to assess students' understanding and knowledge in applying their learnings related to engineering ethics under different circumstances [51-54].

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